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TOPOGRAPHY

WITH

AN APPENDIX ON MAGNETIC OBSERVATIONS

BY

W. I. FARQUHARSON, Lieutenant-Commander, R.N.

WITH SIX PLATES AND SIX CHARTS

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I. ECHO-SOUNDING MACHINE.

This was the Admiralty Recording Echo-sounding Gear, Acadia type, manufactured by Henry Hughes & Son, Ltd.

It is divided into three parts, Transmitter, Hydrophone and Receiver.

Transmitter. (Pl. I, upper fig.)

Fitted below the floor plates of the boiler room and supplied with air at 100 lb. pressure by a small electrical compressor in the engine-room. The transmitter consists of a steel hammer operated by compressed air, the blow being distributed through pressure chambers to the ship's hull. The air supply is controlled by a solenoid operating an electro-magnetic valve in the solenoid housing. The current to this solenoid is supplied from the hammer switch gear in the receiver. After a blow the hammer is lifted to the top of the cylinder again by means of low-pressure air from the main supply passing through a reducing valve.

Hydrophone. (Pl. I, lower fig.)

Mounted on a sluice valve situated on the ship's hull below the fish-hold, the vibrations of an incoming echo being transmitted through a diaphragm to the microphone button.

Receiver. (Pl. II.)

Fitted on the after bulkhead of the wheel-house. This consists of an electric motor operating the switch gear for the transmitter, the amplifier and the recording apparatus. When the main switch is made, current is supplied to the hammer switch gear and thence to the solenoid in the transmitter. This solenoid closes the valve against the air supply from the compressor. The switch gear is revolved by gearing from the electric motor, and as the inner brush passes over the gap the circuit to the transmitter is broken. This allows the air to open the valve and to drive the hammer down. The vibrations of the resulting echo transmit a current from the microphone to the amplifier. Thence the amplified current passes to the stylus traversing the recording paper, which is sensitized by the starch iodide process. Any disturbance reaching the hydrophone is thus recorded on the paper by a dark stain due to the liberation of iodine.

The electric motor revolves the hammer switch gear once every $2\frac{1}{2}$ seconds. This is the time taken for a sounding of 1000 fathoms to reach the bottom and return ; allowing for the double journey it is therefore the equivalent of a velocity of sound of 800 fathoms per second. Gearing from the shaft of the motor also operates two switch drums, and a roller which draws the recording paper downwards. The first of these switch drums allows current to pass to the stylus at the beginning and the end of its passage across the paper, thus marking the zero lines. As the contact for the second zero line is made a quarter of a revolution after the first, the zero lines are thus 250 fathoms apart.

The second switch drum is so connected by gearing to the motor shaft that it only makes contact once in every 24 revolutions of the hammer switch ; thus current is supplied to the stylus to mark the record once a minute.

Phase.

It has been shown that whereas the hammer switch turns through one revolution in a time equivalent to that taken for a sounding of 1000 fathoms to be transmitted and received, the width of the recording paper is only sufficient for a sounding of 250 fathoms. Soundings greater than the latter depth are recorded by advancing the position of the gap by steps of 100 fathoms up to 1000 fathoms. The hammer switch is graduated for these steps, and the reading uppermost on the switch will show the number of hundreds of fathoms to be added to the sounding shown on the record. In depths greater than 1000 fathoms the switch will have passed through one revolution before the echo is received, and similarly in 2000 fathoms it will have completed two revolutions.

In order to ascertain the correct setting of the switch to pick up a sounding a telephone circuit is fitted. The selector switch controls a circuit in series with the hammer switch, and it can be operated so that only one hammer-blow is transmitted. Using the head-phones a blow is transmitted; the number of revolutions made by the hammer switch before the echo returns gives the depth in thousands of fathoms. The position of the brush relative to the graduations on the hammer switch will allow the depth to be read to the nearest 100 fathoms. The switch can now be set to the phase suitable for recording.

Recording Paper.

A drum of paper lies at the back of the receiver and is drawn by the roller over a wick at the top of the tank. The paper is thus sensitized, and after passing under the

stylus is drawn over a heater, which dries it. The record is then ready for measurement. A scale compensated for the shrinkage of the paper is used. The results can then be worked up, the recorded soundings having to be corrected for the difference between the velocity of sound in any particular area and the velocity of 800 fathoms per second for which the machine is graduated.

The motor is controlled by a governor which eliminates fluctuations of the ship's voltage, and it can be adjusted to run the machine for velocities slightly different to 800 fathoms per second. However, complications to the working up of results are introduced if this speed is not adhered to, especially as the time record will no longer represent minutes.

Throughout the Expedition the machine was required to be in use almost continuously while the ship was under way. This meant that on ocean passages the machine was running for periods of 36 hours to 72 hours without stopping. The echo-sounding gear stood up to this test successfully for at least 90% of the work required from it. The time lost was largely due to breakdowns of the transmitter solenoids. While the hammer is in operation there is a certain amount of vibration in the transmitter, which in time damages the insulation of the leads to the solenoid. In the early part of the expedition more time was spent in locating the source of trouble than was necessary later, when experience reduced very considerably the time lost in diagnosing the fault. Apart from the solenoids, no other part of the gear gave any considerable trouble. The hydrophone required no attention whatever, and the air compressor, except for occasional changing of brushes, worked satisfactorily throughout the expedition.

A spare transmitter was carried, and it was necessary to ship this when the cylinder of the original one cracked. This fracture was probably due to fatigue in the metal, as it occurred after the machine had been running continuously for about six months. Towards the end of the expedition the amplifier gave a certain amount of trouble. Two or three of the valves and two of the resistances burnt out, but this also only occurred after they had been working satisfactorily for very long periods. The damaged resistances were replaced by ones provided by the Eastern Telegraph Company at Aden. The damaged solenoids were also repaired at the Seychelles by this company.

Taking into account the lack of a workshop and facilities for carrying out repairs on board, it is considered that the machine ran very successfully. Many of the stoppages would probably have been avoided in a ship carrying a trained electrician with a little time to devote to care and maintenance.

II. COMPARISON BETWEEN ECHO AND WIRE SOUNDINGS.

Station.	Echo.	Sounding wire.	Remarks.
1	1205	1230	An indefinite wire sounding, no bottom-sample obtained.
2	551	560	..
3	1145	1190	Wire not quite up and down.
5	513	520	..
9	134	137	..
10	30	30	..
12	264	260	Not simultaneous.

Station.	Echo.	Sounding wire.	Remarks.
13	226	228	..
15	576	569	Not simultaneous.
16	102	101	..
17	467	472	..
20	619	632	..
21	830	825	Not simultaneous.
23	519	529	..
25	339	345	..
29	1133	1134	..
32	644	659	..
33	708	710	..
34	559	564	..
35	241	246	..
38	1344	1340	..
39	1179	1188	..
47	57	61	..
52	57	55	..
55	434	438	..
58	659	685	Not quite simultaneous on slope.
59	1065	1081	..
61	1257	1265	..
62	1035	1041	..
64	245	245	..
65	496	497	..
66	333	335	..
70	107	108	..
71	56	58	..
76	1798	1804	..
93	2183	2193	..
100	2779	2800	..
106	116	118	..
108	427	432	..
109	350	351	..
110	180	181	..
112	62	64	..
116	140	140	..
117	486	494	..
118	978	980	..
119	658	669	..
120	1603	1593	..
121	506	504	..
122	407	410	..
126	114	116	..
127	2237	2276	..
129	1396	1404	..

Station.	Echo.	Sounding wire.	Remarks.
130	2369	2395	..
132	2232	2302	Not up and down.
133	1851	1918	..
134	2315	2354	..
135	1491	1512	..
137	1039	1060	Wire sounding not definite.
140	284	287	..
143	436	437	..
166	2621	2624	..
167	2210	2220	..
170	2010	2026	..
173	2433	2466	..
180	1031	1084	..
188	289	293	..

The echo sounding was therefore usually about $1\frac{1}{2}\%$ less than the wire sounding. The wire soundings were obtained by using a 'Bigelow' bottom sampler on the hydrographic wire. This wire has a considerably larger cross-section than the Lucas wire usually used, and this greater area exposed to the sub-surface currents probably accounts for the excess of the wire soundings.

III. RED SEA AND GULF OF ADEN.

The soundings in the Red Sea were mainly taken with a view to testing the echo-sounding machine. They were also taken at each place where it was desired to make a station. The soundings obtained were found to be in good agreement with those already charted. The machine was first run in depths suitable for recording between the 100-fathom line in the Strait of Jubal and Hurghada. Its possibilities were illustrated almost immediately, for the record showed, when south-west from Shadwan Island, an uncharted bank rising to 90 fathoms from depths of 291 fathoms on its eastern side and falling to depths of 251 fathoms on its western side.

It was decided to make the first station in the vicinity of the 1265 fathom sounding in latitude 25° 24′ N., longitude 36° 12′ E.—by far the greatest depth charted in the northern end of the Red Sea. The existence of this deep hole was confirmed by the echo. The station was made in a depth of 1205 fathoms.

Gulf of Aden. (Chart 1, and Pl. III.)

Soundings in this area were obtained in the course of five of the ten cruises.

No. 1. At the western end of the Gulf.

No. 2. Between Aden and Berbera, then along the southern side of the Gulf to Cape Guardafui, with the return passage along the northern side of the Gulf.

No. 3. Zigzagging down the centre of the Gulf while on passage from Aden to Karachi.

No. 9. A few soundings were obtained at the eastern end of the Gulf, but not on passage to Aden, due to a failure of the amplifier of the echo-sounding machine.

No. 10. Soundings were obtained in the western end of the Gulf, mainly in the vicinity of those already obtained in No. 1.

The Gulf consists of a series of ridges and troughs in its centre. At the western end the direction of the contours is from east to west. In the middle and at the eastern end the direction of these contours changes to a direction from north-east to south-west.

From the soundings obtained in the western end of the Gulf it appears that the deep gully of over 100 fathoms, which commences in the Red Sea south of the Hanish Islands, can be traced for a further 75 miles into the Gulf.

The gully, after passing to the south-westward of Perim, gradually deepens to 200 fathoms, running parallel to the 100-fathom line. The gully is bounded on its south side by a long spit of less than 200 fathoms running to the eastward from the French Somaliland Coast. About 35 miles to the eastward from Perim the gully deepens to 300 fathoms, and 40 miles further on merges into the general depth of 400 fathoms.

The spit on the southern side of this gully separates it from another and much deeper gully, running out from the Gulf of Tajura.

The westernmost charted indication of this gully is the sounding of 513 fathoms at the entrance to the Gulf of Tajura. It is supposed that this sounding is connected with one of nearly 1000 fathoms obtained by " Mabahiss " at Station 14 in latitude 11° 56′ N., longitude 43° 38′ E. In this position the depth increased very abruptly from a level plateau to the south-east of 260 fathoms and a similar depth to the north. This gully can be traced for a distance of 165 miles to the eastward from Obokh before it merges into the general depth. In all, this gully was crossed seven times, mainly in the vicinity of the 45th meridian, in which positions the depth was neither so great, nor the descent so abrupt. The depths obtained in the eastern lines over the gully varied between 656 and 785 fathoms, the charted depths further to the westward being between 688 and 839 fathoms.

About the 45th meridian the gully is bounded on its northern side by a ridge having depths of between 285 and 350 fathoms, rising from depths of 500 to 600 fathoms which lie still further north. The southern side of the gully rises steeply to depths of a little over 400 fathoms, then deepens gradually to 700 fathoms and more rapidly to 800 fathoms.

The middle and eastern parts of the Gulf appear to consist of a series of ridges running from the north-east to the south-west, though this may be modified at the extreme eastern end where soundings are sparser, and it becomes increasingly difficult to connect the various groups of shallow soundings.

The changes in depth are frequently extremely abrupt. The general depths of the Gulf increase gradually from 900 to 1400 fathoms, although much greater depths occur in places. The ridge that runs south-westward from Ras Fartak was followed for the greater part of its length. The depths on this ridge are between 700 and 800 fathoms, dropping abruptly on its eastern side to over 2000 fathoms. Towards its northern end there are charted two soundings of over 2700 fathoms, representing a descent of nearly 12,000 feet. These depths are considerably greater than any other found in the Gulf of Aden or the Arabian Sea. The ridge is indicated by soundings for a distance of about 120 miles with the gully continuing alongside it. It is about the same height along its whole length,

but the gully decreases in depth until both merge into the general depth of the Gulf. The ridge overlaps the shallow bank extending to the northward from Bander Alula. The depth between the ridge and the bank is about 1300 fathoms, and it appears that water at a greater depth than this has no access to the deeper water outside the Gulf.

The least depths obtained in the middle of the Gulf were two soundings situated near the 50th meridian, one of 325 fathoms, the other of 382 fathoms. These appear to be situated on a ridge running in a similar direction to that from Ras Fartak. This ridge has also a gully on its eastern side with depths of nearly 2000 fathoms. One afternoon was spent in running parallel lines of soundings in the vicinity of the 325-fathom sounding. It appeared as a peak lying in an easterly and westerly direction situated on a ridge of about 900 fathoms running from the north-east to south-west.

Quite possibly less water existed in other parts of the main ridge as the ship's course was parallel to its summit. About 75 miles to the north-eastward of the 325-fathom depth the soundings again shoaled to 382 fathoms. This latter depth was not examined and less water may exist. Another shoal sounding, 200 fathoms, is charted in latitude 14° 28′ N., longitude 53° 11′ E., but not enough soundings have been taken in its vicinity to trace any ridge on which it may be situated.

The gullies appear to be invariably associated with the ridges, the greatest depths being situated immediately to the eastward of the ridges.

The line of soundings run just south of the 12° parallel from the 47th meridian towards Bander Alulu did not reveal any great irregularities, and for the greater part of the way the bottom was quite flat. Similarly, soundings taken parallel to the north coast were regular, with one exception in latitude 13° 39′ N., longitude 48° 17′ E., where the depth rose steeply from 730 fathoms on either side to 520 fathoms. It therefore appears that these ridges, lying in the centre of the Gulf, are not connected with the mainland on either side, but merge into the general depths of the Gulf before reaching the coast. It seems probable that where the general depth in the centre of the Gulf is over 1100 fathoms, the merging of the ridges into the sides of the Gulf takes place at about the 1000-fathom line.

IV. ARABIAN SEA AND ENTRANCE TO PERSIAN GULF. (Chart 2, and Pl. III.)

Soundings were taken in this area throughout the latter half of Cruise 3 and Cruise 4.

Between the Khorya Morya Islands and Ras al Hadd, the approaches to the coast were all similar in appearance, the depth decreasing very rapidly from the 1000 fathom to the 500-fathom line, then more gradually to 250 fathoms, after which it shoals steeply again to about 60 fathoms. The slopes are extremely irregular, consisting of alternate slopes and valleys running out to seaward, in appearance similar to that of a mountain side. While steaming along a course parallel to the shore in the vicinity of the 100-fathom line, the soundings were never constant, varying perhaps from 60 to 360 fathoms in very short distances. The similarity to a mountain side was illustrated by the large quantities of scree dredged off the slopes of the Khorya Morya Islands.

A station was made in the vicinity of the southernmost of the San Carlos Banks, north of Ras Madraka. The bottom sample obtained did not reveal the existence of coral on the bank, and a brief examination of the bank and soundings taken from the dinghy showed no soundings less than 5 fathoms. The published chart shows the bank to have the appearance of a lagoon with soundings of less than 6 feet around its edge, and the nature of the bottom to be coral. The bank appeared to be quite flat with a

general depth of 6 fathoms, and though the examination was too brief to be conclusive, it seems probable, in view of the swell, that if considerably less depths existed, the sea would have been breaking on the weather side of the bank.

Soundings were taken in a position about 13 miles from Ras al Hadd, where H.M.S. " Ranger " reported a shoal sounding of 55 fathoms in 1885. No indications were found to suggest the probability of such shoal water existing, but many irregularities occur between this position and the mainland.

Murray Ridge.

From Ras al Hadd the ship proceeded in an easterly direction to cross the position of a sounding of 951 fathoms charted in latitude 22° 20′ N., longitude 62° 18′ E. The soundings gradually deepened to a level bottom of about 1700 fathoms until this position was reached, when the soundings rose abruptly to 648 fathoms. The ridge was crossed, and in about 2 miles the depth had increased again to 1050 fathoms. Three miles to the northward the depth was 1250 fathoms, the ship then proceeded south and the depth decreased again to 617 fathoms about 2 miles southward of the 648-fathom sounding. Continuing to the southward the depth increased in about 13 miles to 1670 fathoms. This ridge was crossed twice on the next cruise. The first crossing was made diagonally, and the least depth obtained, 480 fathoms, was 55 miles southward from the position of the 648 fathoms ; and the second 104 miles to the southward, when the depth was 1321 fathoms. The general depth in this area is 1820 fathoms. This ridge appears to be the continuation of one of a series of banks that run in a south-westerly direction from Karachi, possibly a submerged connection of the Pab Mountains. It differs, however, in one respect, in that while it appears to be steep to, and uneven on its summit, the others appear to be more in the nature of shelving banks. In longitude 64° E. three separate banks appear. The northern one rises from 1730 to 964 fathoms and falls to 2000 fathoms on its southern side, from which the second ridge rises to 790 fathoms. The third bank rises to 413 fathoms, and is probably separated from the second by a depth of about 1200 fathoms. The soundings on the two northerly banks and the continuation of the third ridge towards Karachi were obtained by " Mabahiss ". The soundings on the summit of the third bank were taken by one of the German cruisers.* The gully of 2000 fathoms that separates the two northern banks is similar to the one that lies on the eastern side of Murray Ridge. It is the existence of these gullies that make it probable that they are connected, and that the Murray Ridge is a continuation of the northern bank.

South of the southernmost crossing of the ridge by " Mabahiss " echo soundings of 2200 and 2300 fathoms were obtained by one of the German cruisers.* As these soundings are comparable in depth only with those obtained in the gully further to the north, it suggests that the gully is continued further to the south. The ridge itself may be continued to the southward, possibly for a great distance, as its track would lead through a group of shallow soundings in latitude 16° N., longitude 60° E. These shallow soundings may, in turn, be connected with the Carlsberg Ridge in the Indian Ocean.

The Makran Basin.

Northward of the line joining Ras al Hadd to the Murray Ridge, the depth increases from 1750 fathoms to 1830 fathoms—the general depth of the basin. This basin appears

* ' Beiheft zu den Nachrichten für Seefahrer,' No. 51, 1932, and No. 25, 1934.

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to have no outlet to water of a similar depth, and the parts traversed by "Mabahiss" showed a perfectly smooth bottom. To the north the basin is bounded by a series of ridges that run parallel to and about 60 miles from the Makran Coast. On the south-eastern side the basin is bounded by the banks running out from Karachi. The north-western arm extends towards the entrance to the Persian Gulf along the southern side of the Gulf of Oman. The north-eastern arm extends for nearly 200 miles, shoaling very gradually, towards the low ground of Sonmiani Bay lying between the Makran Coast Range and the Khirtar and Pab Mountains.

Makran Coast.

The northern edge of the basin is formed by a barrier that usually rises between 400 and 500 fathoms from the general depth. This barrier was crossed eight times by "Mabahiss". In the 60 miles that separate this barrier from the mainland there lies a series of ridges and valleys running parallel to the coast. The ridges appear to be similar to the mountain chains of the coast. The submerged valleys in most cases contain water of depths 200 or 300 fathoms deeper than the barrier. It seems probable that in many cases the water in these valleys is cut off from water of a similar depth in the basin. On the north coast these irregularities appear to continue right up to the 100-fathom line in the head of the Gulf of Oman. The 100-fathom line is by contrast extremely regular.

Oman Coast.

In the Gulf of Oman no soundings as deep as those of 1900 and 2000 fathoms, shown on the published charts, were obtained. On the contrary the depths showed a gradual decrease from 1830 fathoms in the basin towards the head of the Gulf. On the western side of the basin a line of soundings was run about 30 miles off the coast of Oman. Where the depths were less than 1500 fathoms the soundings were very irregular. These irregularities are probably due to spurs running to seaward from the 100-fathom line as happens southward of Ras al Hadd. They may also be due to the presence of submerged valleys and ridges running parallel to the coast similar to those on the Makran Coast. The latter seems to be the case off Muscat.

The sections along the 64th meridian and the parallel 22° 30′ N. were drawn from the contours suggested by soundings in the vicinity. The contours in the vicinity of Murray Ridge are open to doubt. It may be that the three different groups of shallow soundings shown on the ridge are separated by deep water. In this case each group would appear to be continuations of the three banks to the north-westward. A line of soundings run from the entrance of the Gulf of Oman in a south-easterly direction crossing the banks at right angles would settle this question.

The shallow soundings obtained by one of the German cruisers to the southward from Ras Madraka suggest a continuation of the ridge, on which the Khorya Morya Islands are situated, for a long way to the eastward.

V. INDIAN OCEAN AND ARABIAN SEA. (Chart 3, and Pl. IV.)

In all, four crossings of the ocean were made, the first from a position 135 miles east of Masira Island on the Arabian Coast, approximately along the parallel 20° N. towards Bombay, the second diagonally across from Bombay to Mombasa, the third

approximately parallel to the second from a position 250 miles east from Mafia Island to Kardiva Channel in the Maldive Islands *via* the Seychelles; the fourth was made from Kardiva Channel towards Cape Guardafui.

In addition three lines of soundings were run to the eastward of the Maldive Islands.

Carlsberg Ridge.

On each occasion of making the Ocean passage a ridge was crossed dividing the north-eastern and south-western halves of the Ocean.

The northern crossing, with a depth of 480 fathoms rising from 1800 fathoms on the western side and falling to a depth of over 2000 fathoms on its eastern side, has been described in the section on the Arabian Sea and Entrance to Persian Gulf.

The second crossing between latitudes 9° and 10° N. was made in bad weather, the water noises and rapid fluctuations in depth making it impossible to keep a continuous record. The least sounding obtained was 1636 fathoms, but the probability is that less water exists.

The third crossing was in latitude 7° N., and the least depths obtained were 1361, 1209 and 1232 fathoms, and 75 miles to the westward 1578 fathoms. The soundings were all isolated by depths of about 2000 fathoms.

The fourth crossing was between latitudes 1° and 2° N.; the least water obtained was 858 and 958 fathoms, separated by depths down to 2000 fathoms.

In addition to these crossings, the ridge was crossed three times by the German cruisers; one in latitude 11° N., where soundings of 1651, 1673 and 1651 fathoms were obtained; the next between latitudes 1° S. and 0°, where soundings of 1360, 1395 and 1400 were obtained. The southern crossing was in latitude 4° S., the least depth being 1447 fathoms. Less water may exist in the vicinity of these German soundings if the record was not a continuous one.

The ridge was also crossed by the "Dana" in a direction close to our own southern crossing, and it was from the results of this crossing that Dr. Johannes Schmidt postulated the existence of the ridge and gave to it the name Carlsberg.

Apart from these echo soundings, there are charted between the latitudes of Socotra and the Chagos Archipelago a sounding of 850 fathoms in latitude 10° N., and soundings of 1253, 1255 and 1364 fathoms in latitude 3° S., with depths of over 2000 fathoms close to the eastward.

Along the supposed track of the ridge the greatest distance between lines of echo soundings is 500 miles. In this gap only two soundings, each of 2100 fathoms, are charted. As the general depth of the ocean is about 2500 fathoms, and fluctuates with great rapidity in the vicinity of the ridge, these two soundings should indicate the continuity of the ridge.

From the 850-fathom sounding, south-eastward of Socotra, the ridge appears to run south-eastward to the Equator, where it turns to the southward. The existing soundings do not suggest that the highest part of the ridge is connected with the Chagos Archipelago, but that it continues to the southward and is connected to the soundings of 1458 and 1442 fathoms in latitudes 12° S. and 15° S., and that these in turn are part of the ridge on which the Island of Rodriguez is situated.

The existing soundings to the south of Socotra are extremely sparse and erratic, but they suggest that the Island of Abd al Kuri may be situated on a ridge connected to the 850 sounding to the south-eastward, and the possibility that a similar ridge running from the south-eastern extremity of Socotra may exist.

The soundings also suggest that the ridge may turn or branch to the northward before reaching Socotra and be continued a long way, with a possibility of eventually connecting with the 480-fathom sounding obtained in the first crossing of the Arabian Sea.

Until many more soundings are obtained in this area it is not possible to draw with any degree of certainty the contours of the ocean bed.

The first, second and third crossings of the ridge were made approximately at right angles to its general direction. The fourth was made at each end at an angle of about 10° to the ridge, and in the centre at about 30° to the ridge. In the section of this last crossing shown in the diagrams, the presence of the ridge is indicated over more than half of the passage.

The ridge as a whole presents the appearance of a series of sharp folds gradually rising from the bed of the ocean and culminating in two or more folds of approximately equal height.

The section shown for the second crossing is only very approximate, owing to the scarcity of soundings, and only represents the appearance suggested by soundings in the vicinity.

North-Eastern Basin.

The basin lying to the eastward of the ridge has an average depth of 2400 fathoms, and is bounded on the east by the Maldives and Laccadives, to the south by the Chagos Archipelago, and on the north by the bank running to the south-westward from Karachi. That part of the basin sounded over by "Mabahiss" was found to have a consistently smooth bottom except in the proximity of the Carlsberg Ridge, the depth steadily increasing towards the centre of the basin. This basin is probably connected with the deep water to the south-eastward by the channel between the Chagos Archipelago and Addu Atoll, in the centre of which echo soundings of 1900 fathoms were obtained.

South-Western Basin.

The basin to the south-west of the Carlsberg Ridge has an average depth in its northern part of about 2700 fathoms. This basin appears to be connected with deep water to the south between Madagascar and Nazareth Bank on the western side of the Seychelles, and also immediately to the east of the Seychelles. To the north the deep water may be continued up into the Arabian Sea unless Socotra and the Carlsberg Ridge are connected. The Seychelles are situated on a plateau of less than 1000 fathoms stretching from Mauritius through Cargados Carajos, Nazareth Bank and Saya de Malha Bank. The general direction of the northern part of this plateau is to the north-west. The southern part of this south-western basin is therefore divided for a large proportion of its extent.

Soundings in the basin are extremely sparse, consisting mainly of the two lines of soundings run by "Mabahiss", one in the north between Mombasa and Bombay, and the other from Mafia Island towards Kardiva Channel, soundings obtained by ships on the route from Cape Guardafui to the Seychelles, and the echo soundings taken by the German

cruisers between Mombasa, the Seychelles and Maldives. On the route from Cape Guardafui to the Seychelles the depths lie between 2600 and 2900 fathoms, the most notable exceptions being a depth 2044 fathoms situated 150 miles north from the Seychelles, depths of 1200, 2100 and 2200 fathoms about 300 miles from the Seychelles, and a depth of 2000 fathoms 510 miles from the Seychelles. These soundings suggest the possibility of a continuation of the Seychelles plateau to the northward in a modified form. On the other hand, the general direction of the plateau and of the Carlsberg Ridge make it more probable that the contours run in a north-westerly direction in the northern part of the basin. Unfortunately no soundings, except in the immediate vicinity of the islands, exist in this direction from the Seychelles.

The northern line of soundings by "Mabahiss" in this basin only revealed one irregularity, a sounding of 1905 fathoms rising nearly 5000 feet from the surrounding depths, so that with this exception, any ridges that may exist must merge into the general depths of the Ocean before reaching the coast, as appears to be the case in the Gulf of Aden.

The only other marked irregularity, except for those in the immediate vicinity of the Seychelles, was found by "Mabahiss" about 250 miles to the eastward of the Seychelles, a sounding of 1570 fathoms also rising about 5000 feet from the surrounding depths.

The 1905 and 1570 soundings obtained by "Mabahiss", and the soundings of 1200 and 2200 fathoms on the route from Cape Guardafui to the Seychelles, if connected, would lie on a ridge lying parallel to and with, approximately, the same direction as the Carlsberg Ridge. A study of the sections of crossings 2 and 3 in the diagrams emphasizes the similarity of the contours of the 1905- and 1570-fathom peaks and their positions relative to Mabahiss Ridge. If this additional ridge exists, it would appear to branch off the Seychelles-Mauritius Plateau to the north of Saya de Malha Bank.

To the north-westward of the Seychelles certain irregularities do exist. Soundings of 918 and 876 fathoms, rising from about 2000 fathoms on their western and eastern sides, were obtained by "Mabahiss", 34 miles from the bank; still further off, 85 miles from the bank, one of the German cruisers obtained 1566 fathoms. No soundings exist further from the bank in this direction.

These soundings may be the continuation of the Amirante Group to the northward, or of the Seychelles to the north-westward, but regarding the two groups as twin peaks of a single mountain chain, the approaches on the north-western side appear to be considerably less steep than on the other sides. This suggests that the Seychelles-Mauritius Plateau is continued in a modified form for at least a short distance to the north-westward before merging into the general depths of the ocean.

The remainder of the soundings obtained between Mafia and the Seychelles did not show any very marked irregularities; the most prominent were two banks situated about 200 miles to the north-westward of Wizard Reef. These banks, rising 300 and 400 fathoms from the surrounding depths of 2650 fathoms, might be the last of the ridge on which Wizard Reef and the Farquhar Islands are situated.

The western basin therefore appears as generally deeper than the eastern, and sub-divided probably into two further basins, the deep water of one being connected to the southward on the western side of the Seychelles-Mauritius Plateau and of the other on the eastern side with the deep water of the Indian Ocean.

VI. AFRICAN COAST IN THE VICINITY OF MOMBASA AND ZANZIBAR. (Chart 4, and Pl. V.)

The coast between latitudes 3° and 9° S. lies in the form of a gently curving bay about 350 miles long and 70 miles deep. The bay contains Latham Island and the islands of Pemba, Zanzibar and Mafia. To the north of this bay the 1000 and 2000-fathom lines lie only about 27 and 100 miles respectively from the coast. Between the latitudes 3° to 9° S., however, these contours are about 100 and 210 miles from the mainland. Below 9° south the 1000-fathom has again approached to within about 30 miles of the coast. The 2000-fathom line is not shown here, as shoaler water appears to run to the north-westward from the Comoro Islands. The Island of Pemba is separated from the mainland by depths of 500 fathoms in the southern end of the channel and 200-fathoms in the northern end. Latham Island is separated by somewhat similar depths from the mainland. These channels and the relative positions of the 1000- and 2000-fathom contours suggest that the bay was formed by subsidence.

The majority of the soundings obtained and the stations made were inside the islands, only a few lines of soundings being run to seaward. No very great irregularities were found; the ridges appeared to be undulating and of no great height, similar to the coastal hills. The bottom was most irregular off Malindi Point, and several depths of less than 100 fathoms were obtained to a distance of 5 miles outside the charted 100-fathom line. While making the northern end of Pemba from the 1000-fathom line the slope was very gradual until a sharp ridge about 1000 feet high was crossed. This ridge may be a continuation to the southward of the irregularities off Malindi Point. About 40 miles to the eastward of this ridge a bank, slightly shoaler than the surrounding depths, also appears to be a continuation of the irregularities to the northward. Outside Latham Island the slope falls steeply into a channel running between Zanzibar and Pemba. On the outer side of this channel the bottom slopes gently upwards to a bank about 100 fathoms higher than the depth of the channel. On the western side of Latham Island a channel runs towards the 100-fathom line south of Zanzibar. With the exception of the soundings taken at the extreme northern end of this area, the slope below 200 fathoms appears to be extremely gradual.

Inside Pemba Island soundings were obtained showing the slope approaching the island and as necessary for stations. Soundings were also taken in order to verify, if possible, the existence of the 16-fathom sounding charted outside the 100-fathom line off Chaki Chaki Bay. No indications were found, the slope appearing quite normal.

VII. MALDIVE ISLANDS, CHAGOS AND CEYLON. (Chart 5, and Pl. VI.)

The soundings obtained by "Mabahiss" in this vicinity were mainly in Kardiva Channel and its approaches from the westward. In addition, soundings were taken from Colombo towards the Chagos Archipelago, thence northwards between the Atolls to Kardiva Channel. Lines of soundings were also run from Minikoi to Colombo and from Mále to Colombo. Echo soundings taken by a German cruiser between Minikoi and Colombo and Suvadiva Atoll and Colombo were also plotted. From these soundings and those already charted the contours were drawn. The approaches from the westward appear to be quite uniform, and the fathom lines shown probably give a good idea of the slope on this side. On the eastern side and to the south, between Addu and the Chagos,

many irregularities exist, and until many more soundings have been obtained the contours cannot be drawn with any degree of accuracy. A sounding of 296 fathoms to the eastward of Tiladummati is shown in the Bathymetrical Chart published by the Prince of Monaco. Its origin could not be traced and it has been deleted.

In general, the Maldives, Minikoi and the Laccadives appear to be situated on one main ridge, the main ridge being considered as that mass of land which rises above the 1300 fathom line. From 8° N. this ridge runs slightly east of south, is regular in shape and has a fairly uniform width of 80 miles, the slope being steepest on the western side and falling to depths greater than 2000 fathoms. On the eastern side the water deepens to about 1500 fathoms.

From Ihavandiffulu to Kolumadulu the atolls situated on this central mass are all joined below the 700-fathom line, but Mabumudu may be an exception. Above the 1300-fathom line the contours become irregular in shape. At the 300-fathom line, the great majority of the atolls remain connected in a large central group with a small group and two isolated atolls detached. The small group consists of the atolls of Ihavandiffulu and Tiladummati-Miladummadulu, the two isolated atolls being Mabumudu and Fadiffolu, the remaining Atolls from N. Malosmadulu to Kolumadulu being attached to one another.

To the north the Island of Minikoi, Investigator Bank and the Laccadives are all probably connected with the central mass at depths greater than 1000 fathoms. The contours, however, are extremely irregular, and it is these irregularities in slope and contour in the vicinity of Minikoi that lead one to associate Minikoi with the Laccadives rather than with the Maldives.

To the south soundings obtained by "Mabahiss" and one of the German cruisers suggest that the southern atolls of Haddummati, Suvadiva, Addu and the Island of Fua Mulaku are also connected at depths less than 700 fathoms. These atolls may also be connected with the central mass below the 1000-fathom line. This southern mass differs from the others in that its eastern slopes fall to depths as great as those on its western side.

While these three masses are connected, they seem to have the appearance of overlapping, the contours of the northerly one running to the south and then turning south-east along the direction of Investigator Bank towards a sounding of 1159 fathoms in depths of over 1500 fathoms. The central mass commences slightly to the west of the northern one, runs to the southward, the contours then turning towards the south-east, where "Mabahiss" obtained 1709 and 1754 fathoms in depths of about 2200 fathoms (see Chart 3). Similarly the contours of the southern one run south and then appear to swing towards the south-east, where a sounding of 1298 fathoms lies in depths of about 1600 fathoms.

Addu to Kolumadulu.

A line of soundings was run to the eastward from the north-east corner of Addu, at which point the pendulum observations were taken. In this direction the 1000-fathom line was reached 4½ miles from the reef. To the north-east of the atoll the 1000-fathom line lay about 5 miles off. Between these two soundings a ridge rising to 590 fathoms was crossed, and shortly after the second crossing of the 1000-fathom line, another ridge of 654 fathoms was sounded over. If these two are continuous, it suggests a ridge running

to the south from Suvadiva towards Addu and branching off towards the south-east. On the other hand the first of these ridges may be a connection between Addu and Fua Mulaku. From this position onwards the depths deepened uniformly towards the 2000-fathom line.

A line of echo soundings between Haddummati and Suvadiva by one of the German cruisers revealed a depth of 38 fathoms lying midway between the two atolls. To the east and westward of this sounding lie other depths of about 1000 fathoms. The existence of this sounding suggests a submerged connection between the two atolls, or possibly a submerged atoll or reef. It must be remarked that this depth is an exceptional one for the open sea in the Maldives; no other such soundings are charted except in the lagoon entrances.

Off Kolumadulu a section of the slope on the south-eastern side of the atoll was taken, the 1000-fathom line being reached at a distance similar to that off Addu. The few existing soundings between Kolumadulu and Haddummati do not suggest a connection between them above the 1000-fathom line, but such may exist on the eastern side of the channel.

Kolumadulu to Kardiva.

Soundings were taken on the eastern side of the channel that runs north between the atolls. Once the channel was entered, the depths were practically constant at slightly over 200 fathoms. A comparison between these soundings and those already charted show the channel to be slightly deeper on its eastern than on its western side. It is noticeable in those groups of atolls connected by the 300-fathom line that the channels between them running north and south contain water of about 200 fathoms depth, while those running east and west have 270 fathoms. This difference is presumably accounted for by the scour of the currents which run east and west.

Kardiva Channel. (Chart 6.)

The majority of the soundings taken in the Maldives were obtained in Kardiva Channel during that period for which Major Glennie and Lieut.-Comdr. Farquharson were detached for pendulum and magnetic observations. The general depth in the channel is about 270 fathoms. The exceptions to this depth in the eastern end of the channel are in the vicinity of Fadiffolu and Kardiva, Fadiffolu Atoll being surrounded on its inner sides by a trough 400 to 500 fathoms deep. A similar trough, though probably not quite so deep, exists on the inner sides of Kardiva. To the northward of Kardiva Island the depths rose abruptly from over 400 fathoms to a plateau of 160 fathoms before dropping again to the trough lying to the southward of Fadiffolu. The existence of these troughs makes it unlikely that this plateau is directly connected with either Fadiffolu or Kardiva. More probably, the ship passed over the extreme western edge of a bank similar to, but deeper than, the bank to the south of Horsburgh.

On the eastern side of South Malosmadulu the depths are over 300 fathoms, but this trough is not continuous with that on the western side of Fadiffolu, as a steep ridge rising to 244 fathoms divides them.

On the western side of Kardiva Channel, to the north and immediately to the south of Horsburgh, the depths are typical of the channel. Further to the south lie King Fuad Bank, Toddu Island and Rasdu, these possibly all being detached portions of Ari Atoll.

The depths separating these three range from 140 to 166 fathoms, soundings more usual to the western side of the channel running north and south between the atolls than to a channel running east and west. It may be that the projection of Mále Atoll to the northwards shields these atolls from the scour of the west-going current.

King Fuad Bank, so named by permission of His Majesty the King of Egypt, has the appearance of being a sunken atoll. The Bank has the ordinary characteristics of an atoll, having generally a clearly defined rim about 40 feet high. The depth of the level floor inside is 130 fathoms. On the western side the slope rises steeply from the 1000-fathom line as the bank is approached.

A section of the slope from the west side of South Malosmadulu was run out to the 1000-fathom line. The three sections run in the Maldives are all similar in appearance. The depth increased rapidly to 200 fathoms, then less steeply to 400 fathoms. At 400 fathoms the slope steepened again down to 800 fathoms, where it tended to flatten out before dropping again to 1000 fathoms and more.

Minikoi and Investigator Bank.

Soundings taken while steaming to the eastward from Minikoi deepened to 1200 fathoms when about 7 miles from the island. Shortly afterwards they became irregular, rising to depths of a little over 900 fathoms. These irregularities persisted for a distance of about 30 miles, when the water deepened rapidly to over 1400 fathoms. This bank would appear to be a continuation of Investigator Bank to the south-eastward. In the same direction, but about 57 miles further out, a sounding of 1159 fathoms was obtained by one of the German cruisers in a general depth of over 1500 fathoms. It is possible that this is also situated on the same bank.

Soundings to the Eastward of the Maldives.

The soundings obtained by "Mabahiss" on passage from Mále towards Colombo deepened rapidly to 1200 fathoms after leaving the atoll and then gradually to depths of over 1400 fathoms. When 80 miles from Mále, they then shoaled slowly to depths between 1130 and 1150 fathoms. This shelving bank is about 65 miles in width and is divided by a trough of slightly greater depth. The bank appears to be a continuation southward from Cape Comorin of the mainland, and runs in a direction nearly parallel to the Maldive Ridge. A sounding of 1709 fathoms rising from 2200 fathoms obtained on a later cruise suggests that this bank may turn towards the south-east about latitude 3° N. However, this sounding was the peak of a ridge only about 10 miles in width. In contrast with the deep water immediately to the southward of Ceylon, the 2000-fathom line is not met with south of Cape Comorin until 270 miles from the mainland. Between the northern part of the Maldives and the 1000-fathom line off the Indian Coast, lies a basin of water between 1500 and 1640 fathoms deep. It does not appear that this basin has any connection with water of similar depth to the south-eastward.

To the eastward of the Cape Comorin Bank another arm of the bank runs in a south-eastern direction. This part of the bank has a gradual slope, and rises to a depth of 1554 fathoms from depths of 2200 with a width of about 100 miles. Between this arm and Ceylon a deep trough runs up into the Gulf of Manár. In the centre of this trough a shoal of 34 fathoms was reported in 1924. A line of soundings by "Mabahiss" passes

close to its reported position, but gives no indication of its existence. However, about 30 miles to the north-westward of this position a sounding of 1288 fathoms was obtained, rising from 1800 fathoms, which is the general depth of the trough in this vicinity. This is evidence that a ridge does lie in the trough, but that it rises to such heights as 34 fathoms seems improbable.

Whilst on passage from Minikoi to Colombo, soundings were taken on Wadge Bank, south of Cape Comorin, to obtain, if possible, indications of the 5-fathom patch reported on the bank. The least water obtained was 32 fathoms, and the bank appears to shelve gently and is not much in contrast with the surrounding depths.

Colombo to Chagos.

After the 2000-fathom line in about 3° N. was crossed the water deepened to a little over 2200 fathoms, until two ridges of 1709 and 1750 fathoms respectively, in latitude 2° N., were crossed; after this the water gradually deepened to 2500 fathoms about 110 miles to the eastward of Addu.

Chagos to Addu.

Soundings were obtained with difficulty and not continuously in this area, owing to the cylinder of the echo-sounding machine being fractured. The spare transmitter was shipped whilst making a station in the centre of the channel.

From the depth of 2500 fathoms the soundings shoaled rapidly to a little over 1600 fathoms, and became irregular. Two ridges rising from this depth were crossed, one of 1298 fathoms situated 82 miles to the south-eastward from Addu, and the other of 1383 fathoms 115 miles to the southward of the atoll. From the latter ridge the depths increased towards midchannel, where they were just under 2000 fathoms, decreasing again towards Chagos.

Enough soundings have not been obtained in the channel to show that no ridge connects the Maldives and the Chagos. The sounding of 1196 fathoms obtained by a German cruiser to the north of Speaker Bank suggests that less water may exist to the westward of the soundings obtained by "Mabahiss". It seems probable, however, that a trough of about 2000 fathoms connects water of this depth on the western side to that on the eastern.

It is noticeable that to the westward of the Maldives the tendency of the contours is to run towards the south-west, turning towards a little west of south. On the eastern side the contours in the Indian Ocean run to the south and turn towards south-east.

VIII. APPENDIX: MAGNETIC OBSERVATIONS.

The magnetic observations taken in the atolls of Fadiffolu and South Malosmadulu in the Maldives were submitted to the Astronomer Royal for consideration. It is considered that, while the mean of the whole series will furnish valuable data for the correction of the existing charts of dip and horizontal force, the series is insufficient to give reliable information as to local disturbance in the magnetic field.

These observations were carried out in conjunction with Major Glennie's pendulum

observations. The gravity stations were situated, one on the eastern and one on the western extremes of Fadiffolu, the remainder in South Malosmadulu, on the eastern and western extremes, and two in the centre of the atoll.

Magnetic observations were taken at these stations, and four additional ones in South Malosmadulu, making eight in all in this atoll, which was the maximum that time permitted. The necessary transport was carried out by means of a native sailing craft. It was realized that the area of the two atolls was much too large a one to be covered in a time limit of ten days. For that reason half the observations were taken on the western side of Malosmadulu in order that one part of the area should be covered comparatively closely, as far as the selected positions for gravity observations and the exigencies of transport would allow.

However, the results show that in order to ascertain with any degree of certainty the local abnormalities and to eliminate personal and instrumental errors and diurnal variations, a considerably longer time should be allowed for a survey of this nature. The existence of fixed marks and a triangulation would enable the observer to obtain the deflections without the necessity of erecting the instrument in the sun to obtain true bearings. The value of P, which should be constant, was found to have a large range due to a certain extent to the setting of the magnets not being sufficiently accurate, and also to the large range in temperature. Some of the vibrations were obtained during a range from 28° C. about sunrise to about 55° C. two hours later when the sun was well up. The dip observations which were not liable to these errors did not suggest the existence of any marked disturbances.

Maldive Islands: Magnetic Observations, March–April, 1934.

The following observations are the observed values and are not corrected for diurnal variation.

Kew magnetometer, Dover 161. Dip circle, Dover 188.

Place of observation.	Declination.		Inclination.			Horizontal force.		
	Date.	West.	Date.	Needle.	S.	Date.	By deflections.	By vibrations.
Difuri Island.	March 30.		March 30.			March 30.		
Fadiffolu.	12.00	3° 44′ 05″	09.00	No. 1.	6° 37·3′	15.00	0·38096	0·38100
5° 23′ 36″ N.	18.00	3° 42′ 30″	10.00	No. 2.	6° 32·9′	17.40		
73° 38′ 06″ E.	Mean	3° 43′ 18″	Mean		6° 35·1′			
Kanifuri Island.	April 1.		April 1.			April 1.		
Fadiffolu.	10.30	3° 32′ 10″	06.00	No. 1.	6° 00·6′	11.40	0·38029	0·38068
5° 22′ 12″ N.	15.00	3° 31′ 30″	06.45	No. 2.	5° 59·2′	14.00		
73° 19′ 12″ E.			16.00	No. 1.	6° 03·5′			
			16.45	No. 2.	6° 02·1′			
	Mean	3° 31′ 50″	Mean		6° 01·3′			
Fonimagudu.	April 2.		April 3.			April 2.		
Malosmadulu.	13.00	3° 33′ 49″	06.15	No. 1.	6° 44·9′	14.20	..	0·37884
5° 15′ 54″ N.	18.00	3° 37′ 22″	07.15	No. 2.	6° 37·6′	16.15		
73° 10′ 24″ E.	Mean	3° 35′ 35″	Mean		6° 41·3′			

Place of observation.	Declination.		Inclination.			Horizontal force.		
	Date.	West.	Date.	Needle.	S.	Date.	By deflec-tions.	By vibra-tions.
Landa Girava.	April 3.		April 3.			April 3.		
Malosmadulu.	11.30	4° 03′ 26″	14.45	No. 1.	6° 38·1′	12·00	0·38067	0·37994
5° 18′ 00″ N.	14.00	4° 02′ 59″	16.00	No. 2.	6° 37·4′	13.50		
73° 05′ 18″ E.	Mean	4° 03′ 13″	Mean		6° 37·8′			
Doomfano.	April 4.		April 4.			April 4.		
Malosmadulu.	09.30	4° 41′ 26″	13.45	No. 1.	6° 55·9′	10.10	0·37987	0·38057
5° 12′ 21″ N.	12.30	4° 41′ 21″	14.45	No. 2.	6° 54·2′	12.25		
73° 06′ 00″ E.	Mean	4° 41′ 23″	Mean		6° 55·0′			
Mamadu.	April 5.		April 5.			April 5.		
Malosmadulu.	10.00	3° 34′ 20″	06.15	No. 1.	6° 49·6′	09.15	0·38004	0·38002
5° 13′ 30″ N.	13.30	3° 35′ 56″	07.15	No. 2.	6° 49·2′	10.30		
73° 03′ 36″ E.	Mean	3° 35′ 08″	Mean		6° 49·4′			
Mandu.	April 6.		April 5.			April 6.		
Malosmadulu.	06.30	3° 35′ 20″	17.00	No. 1.	6° 49·6′	07.10	0·37903	0·37892
5° 11′ 30″ N.	09.30	3° 37′ 25″	17.45	No. 2.	6° 47·6′	10.00		
72° 58′ 00″ E.	Mean	3° 36′ 22″	Mean		6° 48·6′			
Megili.	..		April 6.			April 6.		
Malosmadulu.			15.00	No. 1.	6° 46·3′	12.30	0·37884	0·37831
5° 11′ 24″ N.			15.45	No. 2.	6° 52·0′	14.30		
72° 55′ 06″ E.			Mean		6° 49·2′			
Kanifuri.	April 7.		April 7.			April 7.		
Malosmadulu.	11.30	3° 44′ 56″	16.00	No. 1.	7° 07·4′	13.10	0·37919	0·37906
5° 02′ 12″ N.	14.00	3° 44′ 59″	17.00	No. 2.	7° 06·4′	15.30		
72° 55′ 15″ E.	Mean	3° 44′ 58″	Mean		7° 06·9′			
Toradu.	April 8.		April 8.			April 8.		
Malosmadulu.	13.00	3° 19′ 12″	16.30	No. 1.	7° 03·2′	13.10	0·37995	0·38091
5° 02′ 42″ N.	15.00	3° 20′ 12″	17.30	No. 2.	7° 02·2′	15.30		
72° 48′ 42″ E.	Mean	3° 19′ 42″	Mean		7° 02·7′			

LIST OF CHARTS.

CHART 1.—Gulf of Aden.

CHART 2.—Arabian Sea and Gulf of Oman.

CHART 3.—Indian Ocean and Arabian Sea.

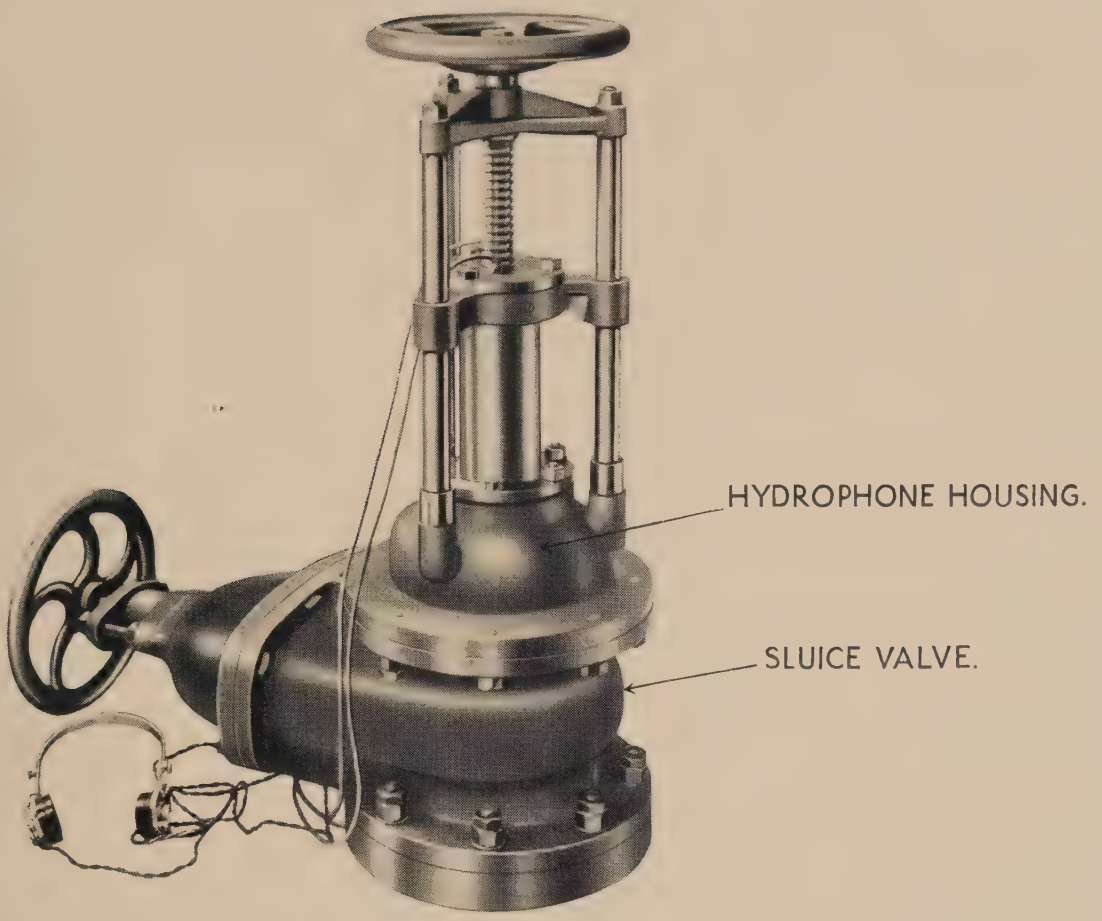
CHART 4.—African coast in the vicinity of Mombasa and Zanzibar.

CHART 5.—The Maldive Islands.

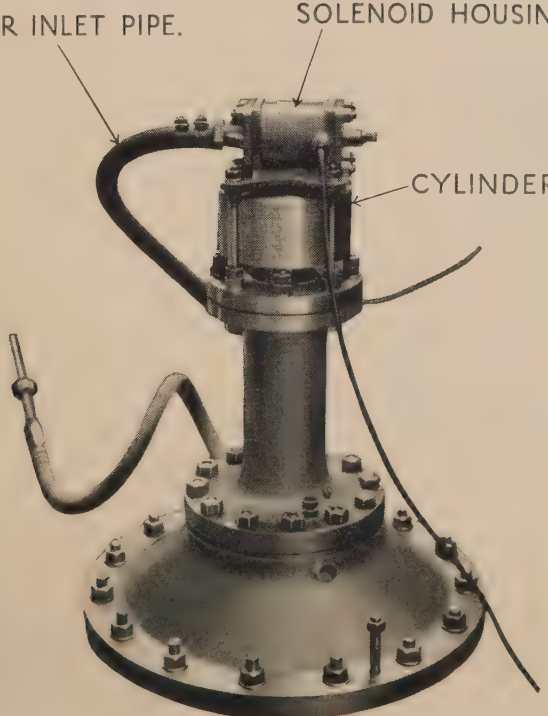
CHART 6.—Kardiva Channel.

DESCRIPTION OF PLATE I.

Hydrophone (above) and Transmitter (below) of the Admiralty Recording Echo-Sounding Apparatus, Acadia type.



HYDROPHONE.

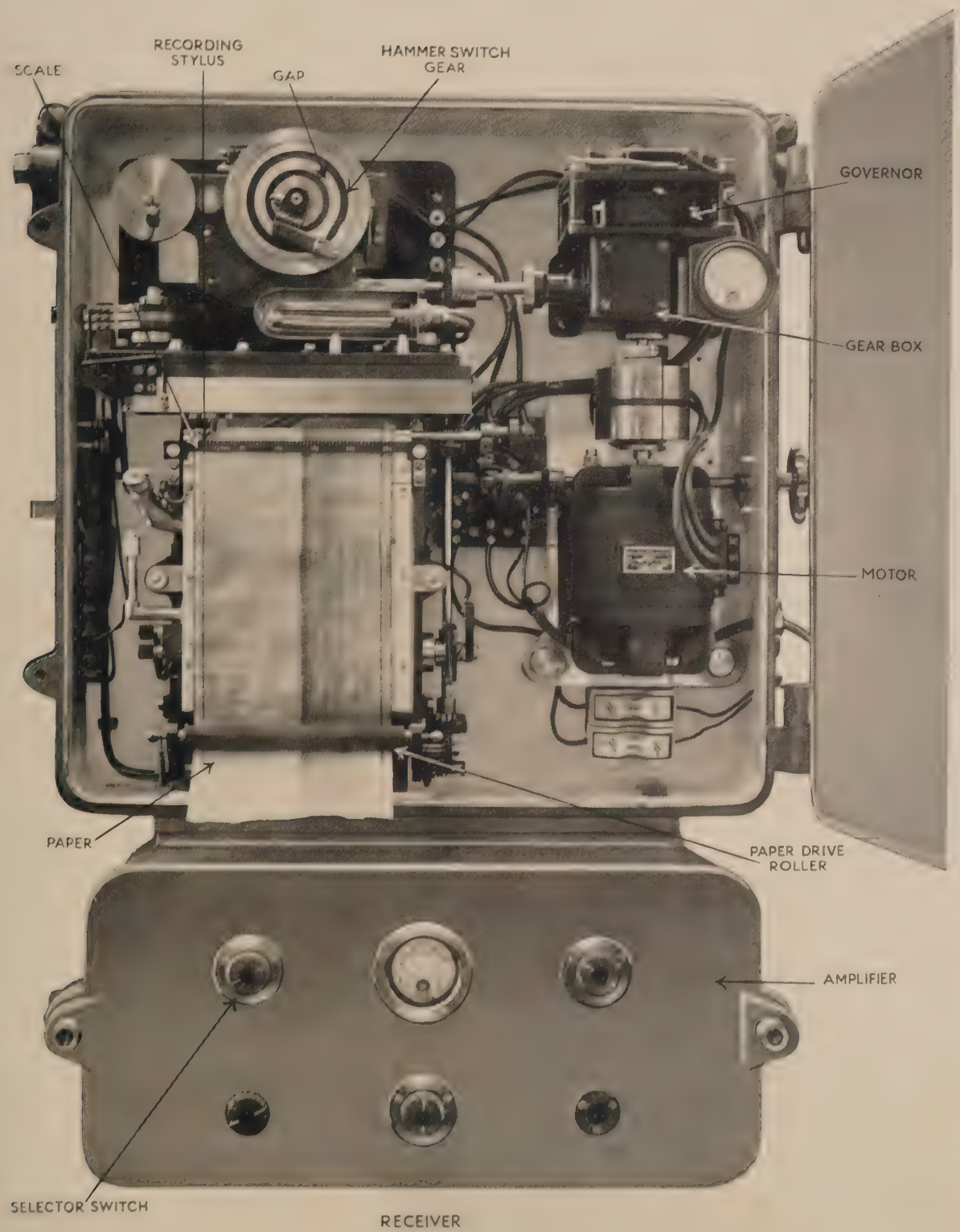


TRANSMITTER.

[*Adlard & Son, Ltd., Impr.*

DESCRIPTION OF PLATE II

The Receiver of the Admiralty Recording Echo-Sounding Apparatus—Acadia type



RECEIVER

[*Adlard & Son, Ltd., Impr.*

DESCRIPTION OF PLATE III.

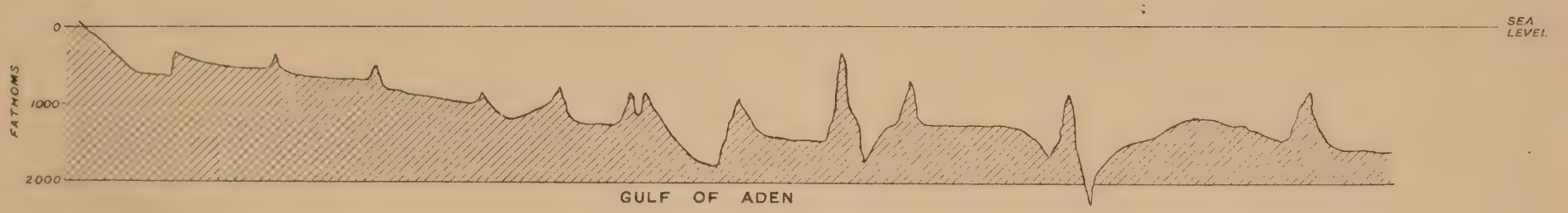
Sections in Gulf of Aden and Arabian Sea.

GULF OF ADEN

SECTION DOWN CENTRE OF GULF OF ADEN FROM OBOKH TO 13°30N. 54°00E.

VERTICAL SCALE ½" = 1000 FATHOMS OR 1 SEA MILE.

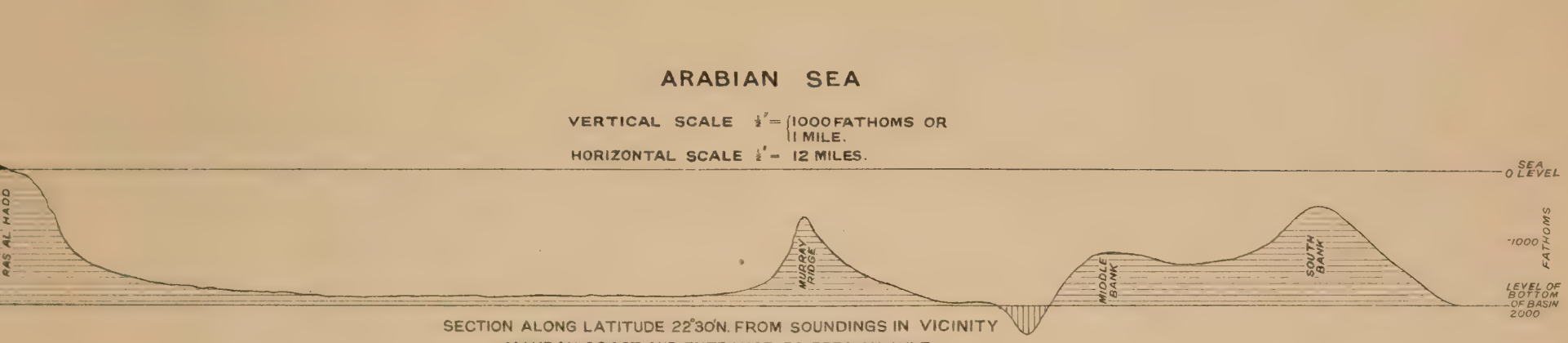
HORIZONTAL SCALE ½" = 38 SEA MILES.



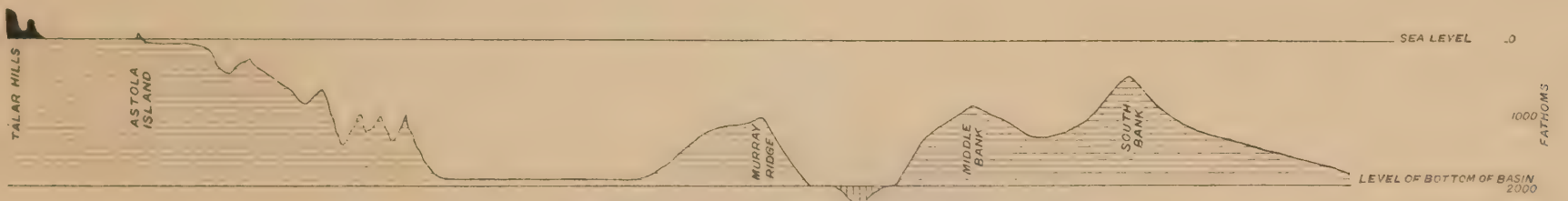
ARABIAN SEA

VERTICAL SCALE ½" = 1000 FATHOMS OR 1 MILE.

HORIZONTAL SCALE ½" = 12 MILES.



SECTION ALONG LATITUDE 22°30N. FROM SOUNDINGS IN VICINITY MAKRAN COAST AND ENTRANCE TO PERSIAN GULF.



MAKRAN AND ENTRANCE TO PERSIAN GULF.
SECTION DRAWN ALONG 64TH MERIDIAN FROM SOUNDINGS IN VICINITY.

Brit. Mus. (Nat. Hist.) JOHN MURRAY EXPEDITION, 1933-34. Reports, Vol. I, No. 2. Plate III.

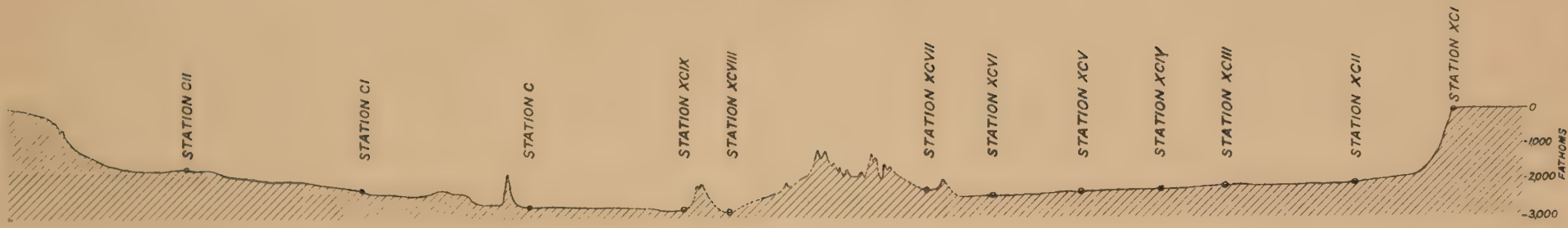
DESCRIPTION OF PLATE IV.

Sections in Indian Ocean.

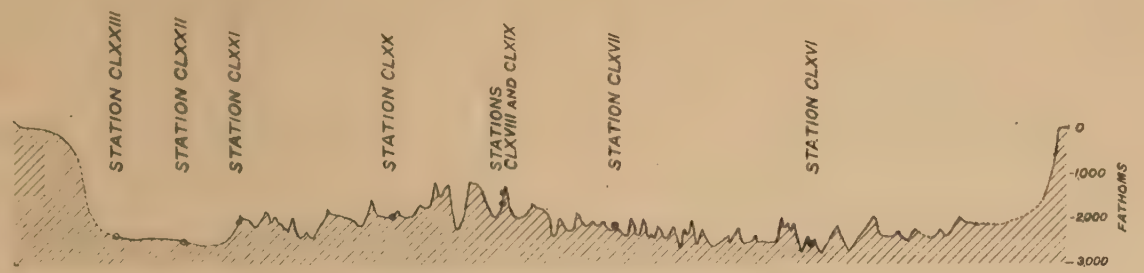
INDIAN OCEAN

VERTICAL SCALE 1" = 2000 FATHOMS OR 2 MILES.

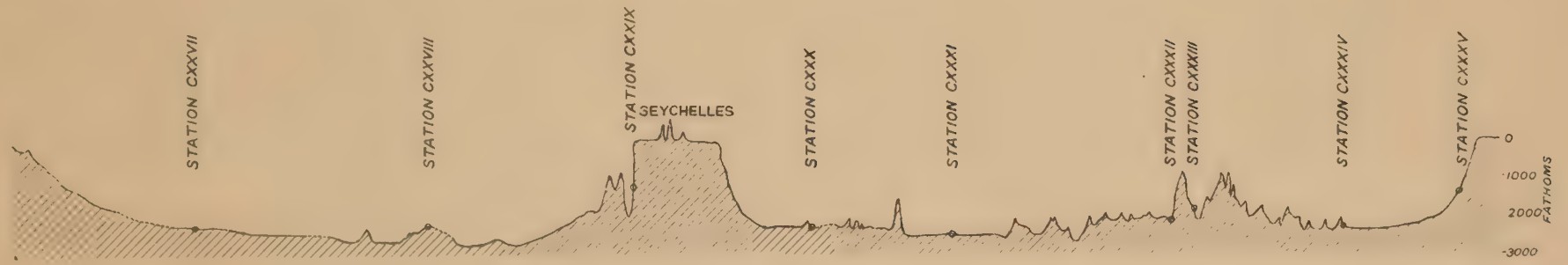
HORIZONTAL SCALE 1" = 115 MILES.



POINT MALINDI TO BOMBAY.



RAS HAFUN TO KARDIVA CHANNEL.



ZANZIBAR TO KARDIVA CHANNEL.

Brit. Mus. (Nat. Hist.)
JOHN MURRAY EXPEDITION, 1933-34.
Reports, Vol. I, No 2.
Plate IV.

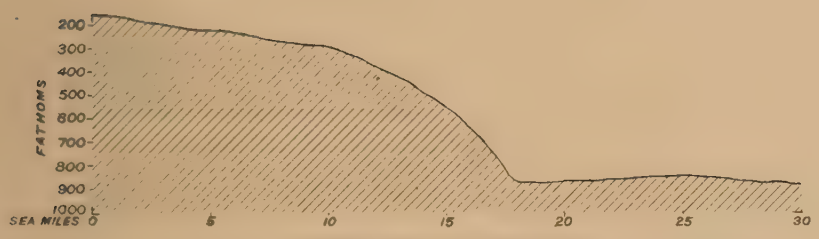
DESCRIPTION OF PLATE V.

Sections off Zanzibar and Pemba.

JOHN MURRAY EXPEDITION, 1933-34.
Reports, Vol. I, N° 2.

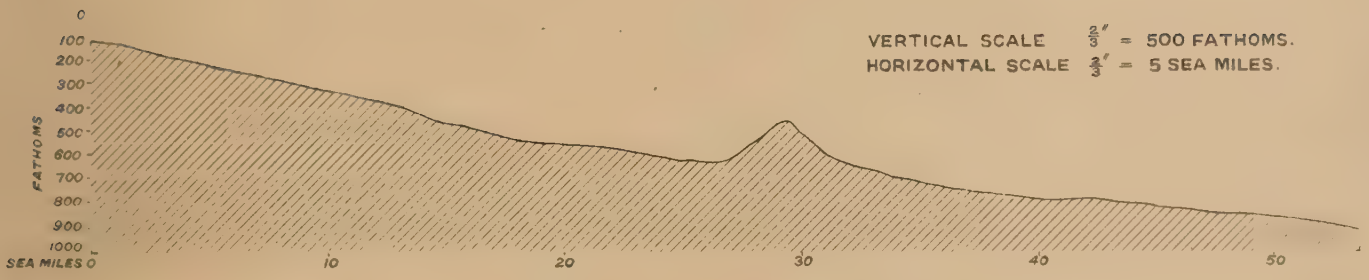
Brit. Mus. (Nat. Hist.)

ZANZIBAR AND PEMBA



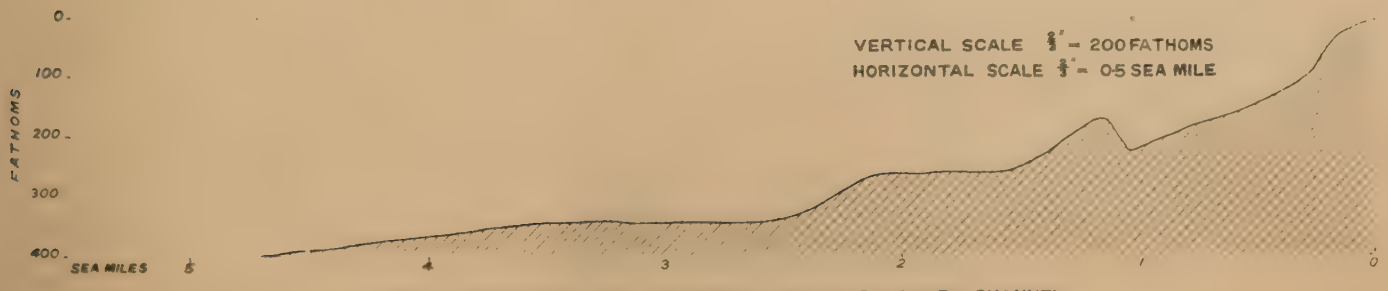
VERTICAL SCALE $\frac{2}{3}''$ = 500 FATHOMS.
HORIZONTAL SCALE $\frac{2}{3}''$ = 5 SEA MILES

SLOPE TO SEAWARD FROM SOUTHERN POINT OF ZANZIBAR.



VERTICAL SCALE $\frac{2}{3}''$ = 500 FATHOMS.
HORIZONTAL SCALE $\frac{2}{3}''$ = 5 SEA MILES.

SLOPE TO SEAWARD FROM 100 FATHOM LINE NORTH OF PEMBA.



VERTICAL SCALE $\frac{2}{3}''$ = 200 FATHOMS
HORIZONTAL SCALE $\frac{2}{3}''$ = 0·5 SEA MILE

SLOPE ON WESTERN SIDE OF PEMBA: EAST SIDE PEMBA CHANNEL.

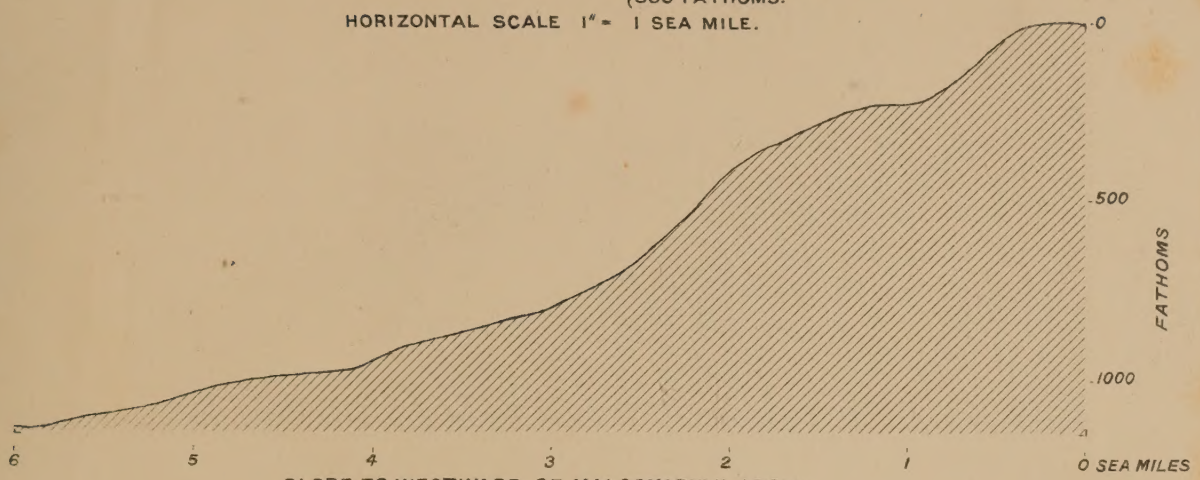
DESCRIPTION OF PLATE VI.

Sections off Maldive Islands.

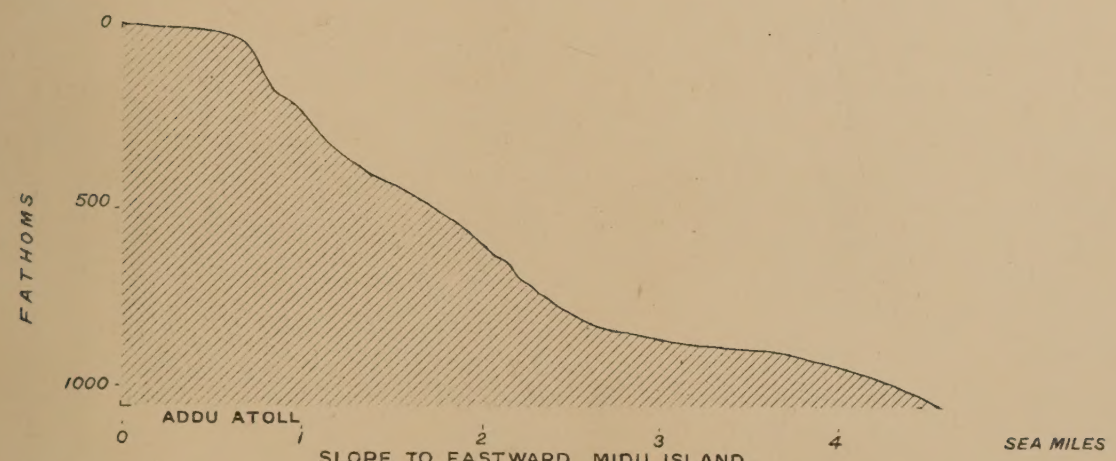
MALDIVES

VERTICAL SCALE 1" = {0·5 SEA MILES OR 500 FATHOMS.

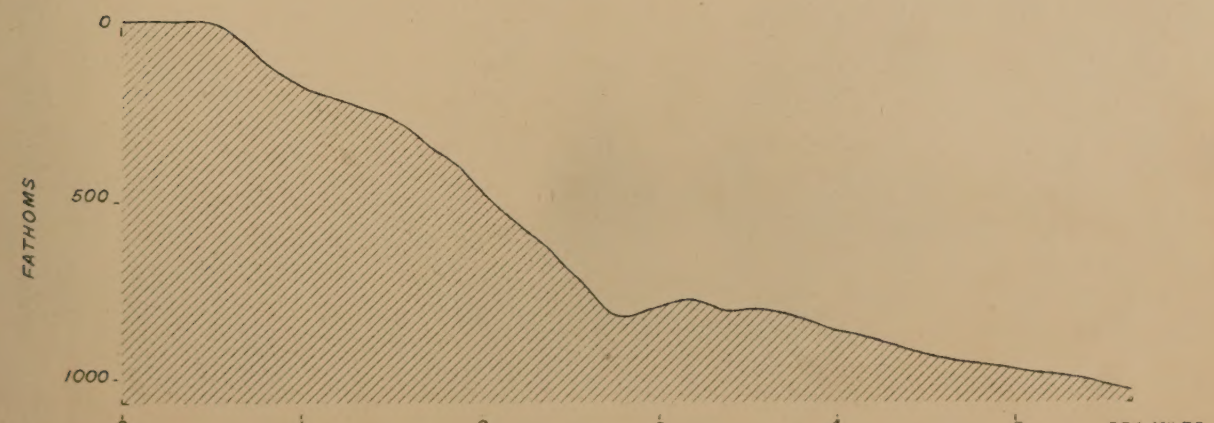
HORIZONTAL SCALE 1" = 1 SEA MILE.



SLOPE TO WESTWARD OF MALOSMADULU ATOLL.



SLOPE TO EASTWARD MIDU ISLAND.



SLOPE TO EASTWARD OF KOLUMADULU ATOLL